RESEARCH DEPARTMENT

# The protection ratio required by an asymmetric-sideband, frequency-modulated monochrome television signal against an unwanted c.w. signal

RESEARCH REPORT No. EL-9

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THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

# THE PROTECTION RATIO REQUIRED BY AN ASYMMETRIC-SIDEBAND, FREQUENCY-MODULATED MONOCHROME TELEVISION SIGNAL AGAINST AN UNWANTED C.W. SIGNAL

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SUMMARY

*This report describes subjective tests which were made to determine the protection ratio required by an asymmetric-sideband, frequency-modulated monochrome television signal in order to reduce interference from an unwanted c.w. signal to a "just not perceptible"* level.*

## 1. INTRODUCTION

Frequency-modulated signals are used in devices such as video-tape recorders and advanced field-store standards converters[1] in order to minimize the effects of gain variations in the transmission path between input and output. Further, asymmetric-sideband f.m. systems are usually employed owing to the relatively narrow bandwidths available in the transmission paths of such devices.

Television broadcasting employs amplitude modulation for the vision signal and the protection ratios required for asymmetric-sideband a.m. systems have been well established[2]; no such information appears available, however, for the corresponding f.m. systems.

During the development of a field-store standards converter it was necessary to determine the ratio of the level of a transmitted f.m. monochrome television signal to that of an unwanted c.w. signal for which the resultant interference patterns were "just not perceptible". This ratio will be regarded, for the purposes of this report, as the "protection ratio" and should not be confused with the protection ratios given in Reference 2 which are described as "acceptable for a small percentage of the time, not precisely defined, but assumed to be between 1% and 10%".

## 2. DETERMINATION OF THE PROTECTION RATIO

Subjective tests were carried out using a monochrome 625 line, 50 field signal and an f.m. system with the following parameters:

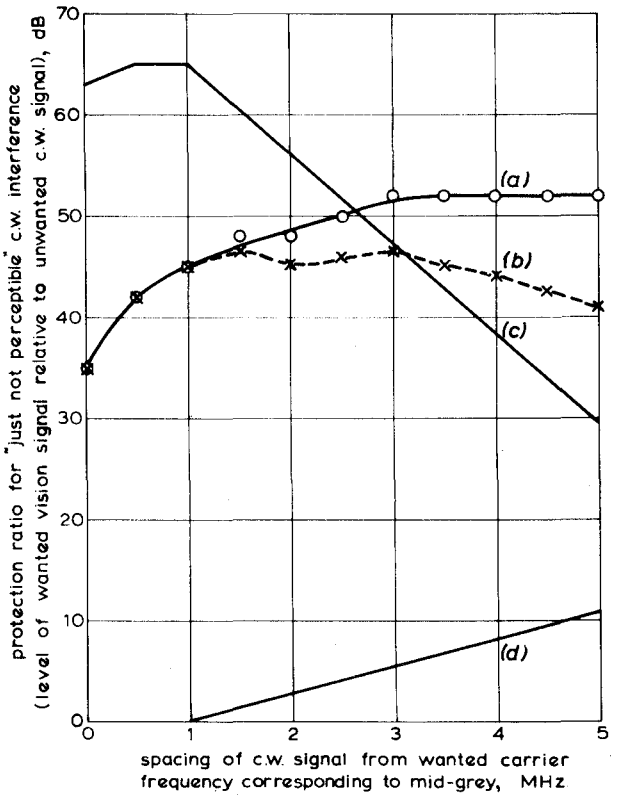
| | |
|---|---|
| Video bandwidth | 5·5 MHz |
| R.F. bandwidth | 7·5 MHz |
| Vestige bandwidth | 2·0 MHz |
| Frequency deviation (black-level to white-level) | 2·0 MHz |
| R.F. pre-emphasis | None |
| R.F. de-emphasis | None |
| Video pre-emphasis | None |
| Video de-emphasis | None |

In practice, r.f. pre-emphasis and de-emphasis would be used with the system which would then have a performance (with respect to signal-to-noise ratio) comparable to a conventional a.m. system, but the necessary filters were not available when the interference tests were conducted. Instead correction was applied to the result obtained with no r.f. pre- and de-emphasis.

Test card "C" was used as the picture for the tests and the interfering signal was a single c.w. carrier. Observations were made using a television monitor with a screen diagonal size of 0·53 m (21 in.); the ambient illumination was such that the luminance from the unexcited monitor screen was 1·7 cd/m$^2$ (0·5 ft-L) and the displayed white brightness was about 70 cd/m$^2$ (20 ft-L). Several skilled observers viewed the television monitor at distances ranging from three to six times the picture height, and each, in turn, adjusted the picture contrast so that the pattern produced by a relatively high level of interference had maximum visibility. In each case, the level of interference was then lowered until the observer judged that the pattern had just disappeared. This was a well-defined threshold

* This is the highest level of interference consistent with grade 1 in the EBU six-point impairment scale.

and the observers usually agreed on the "just not perceptible" level to within 2 dB. Observations were made with different frequency offsets between the wanted carrier frequency representing mid-grey and the interfering carrier frequency; it was not deemed necessary to adjust this spacing critically since, unlike a.m. systems, a clear condition of "precision-worst" frequency offset does not occur with f.m.




*Protection ratio required for "just not perceptible" interference from a c.w. signal*

(*a*) Measured f.m. protection ratio with no pre- or de-emphasis
(*b*) Measured f.m. results assuming use of pre- and de-emphasis
(*c*) a.m. protection ratio
(*d*) f.m. pre-emphasis characteristic

The results of the tests are shown in the figure which gives the actual measured results, the r.f. pre-emphasis characteristic which would be used in practice, and the correspondingly corrected protection ratios. For comparison the figure also shows the protection ratios required for an a.m. system; these have been derived by adding 15 dB to the values given in Fig. 24 of Reference 2 in order to obtain values corresponding approximately to the "just not perceptible" criterion used in this report. (The justification for this procedure is the statement in Section 3.2 of the same Reference that "protection ratios for just perceptible interference would be some 10 to 20 dB higher" than those given in Fig. 24. Although the full 20 dB allowance permitted by Reference 2 might have been taken, it was considered prudent to "split the difference" between 10 dB and 20 dB in order to avoid over-optimism in assessing the advantage of f.m. over a.m.)

## 3. DISCUSSION OF RESULTS

The figure shows that, on the whole, the f.m. protection ratios are lower than those required for a.m., the advantage being about 25 dB for a spacing of 0·5 MHz or less between the wanted and unwanted carriers, reducing to 0 dB for a spacing of about 3 MHz when pre- and de-emphasis are used. This "triangular" difference characteristic is broadly consistent with the theoretical resistance of an f.m. system to a small interfering c.w. signal; the interfering signal modulates both the amplitude and the phase of the wanted carrier but the f.m. detector responds only to the phase modulation which, with no r.f. de-emphasis, produces an output proportional in amplitude to the frequency difference between the wanted and unwanted signals.

An effect which tends to reduce the visibility of c.w. interference with an f.m. system is that the beat frequency between wanted and unwanted signals is itself frequency-modulated. With an a.m. system the interference takes the form of a uniform striped pattern over the whole picture; with an f.m. system the interference produces pseudo-random zig-zag patterns.

## 4. CONCLUSIONS

Protection ratios corresponding to "just not perceptible" interference have been determined for a particular transmission system which could be used for conveying a 625 line, 50 field monochrome signal through a field-store standards converter.

Limited tests show that such a monochrome television transmission system employing frequency modulation tends to be less affected by an unwanted c.w. signal than a conventional amplitude-modulated system.

## 5. REFERENCES

1. Field-store standards conversion : A comparison of amplitude and frequency modulation systems. BBC Research Department Report No. T-166, Serial No. 1966/14.

2. Technical data used by the European V.H.F./U.H.F. Broadcasting Conference, Stockholm 1961, (Geneva), International Telecommunication Union, 1963.



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